



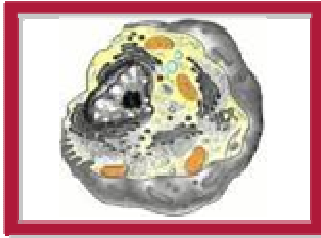
Energetiq Soft X-Ray Light Source

2010 International Workshop on EUV Sources

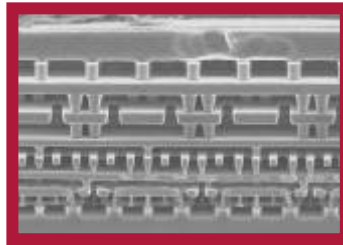
*Debbie Gustafson, Matt Partlow, Paul Blackborow,
Steve Horne, Matt Besen, Don Smith*

Working at the Nano-Scale....

Mammal Cell



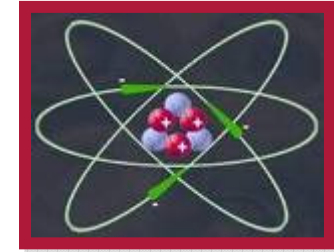
Microelectronics



Protein Molecule



Atom



10 μm Size 1 μm / 1000 nm 100 nm 10 nm 1 nm 0.1 nm
/Wavelength

Infra-red

Visible

Ultra-violet

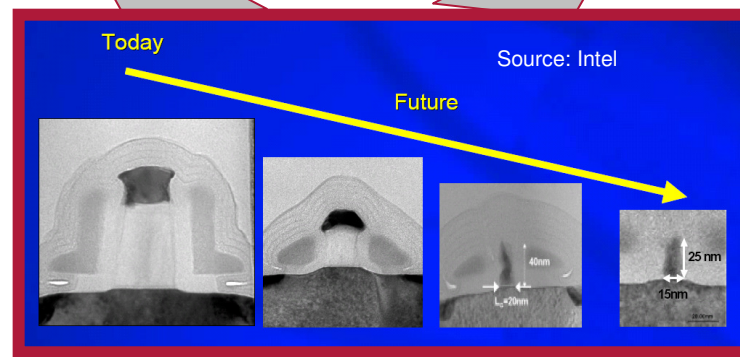
Extreme
Ultra-Violet

Soft X-Ray

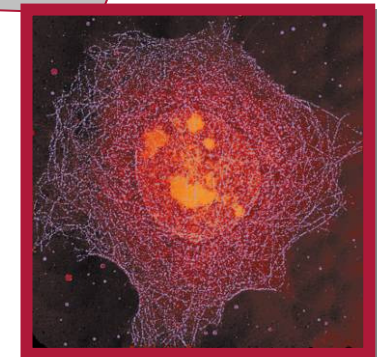
Hard X-ray



To see and make
nano-scale
structures, you
need nanometer
scale light

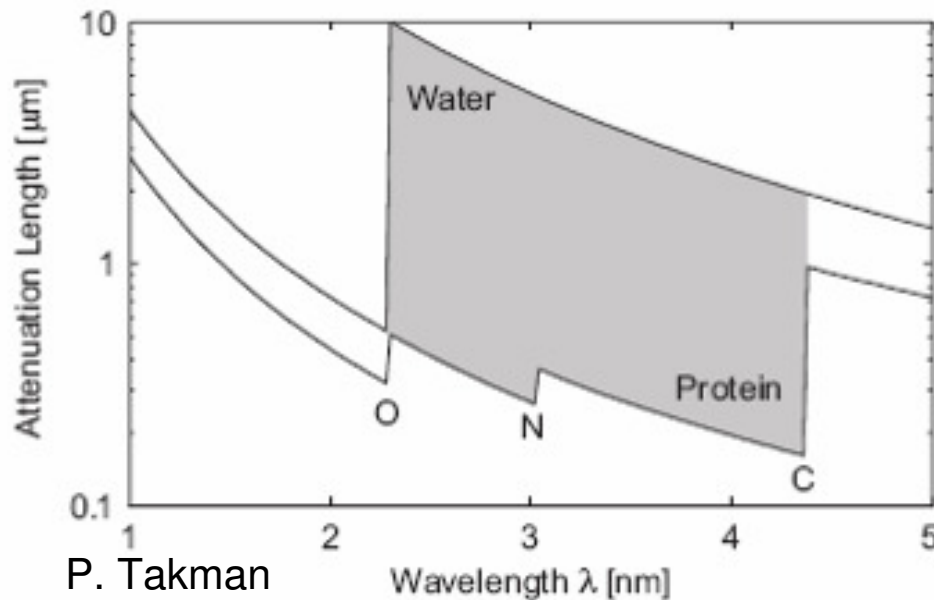


Advanced Semiconductor Chips

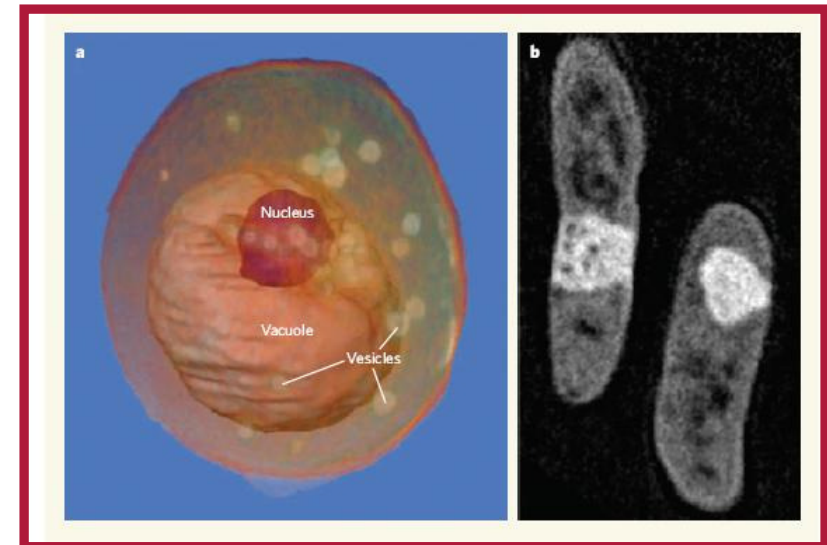


Soft X-Ray Microscopy

Soft X-Ray Biological Imaging



Soft X-Ray Nanotomography of a Yeast Cell



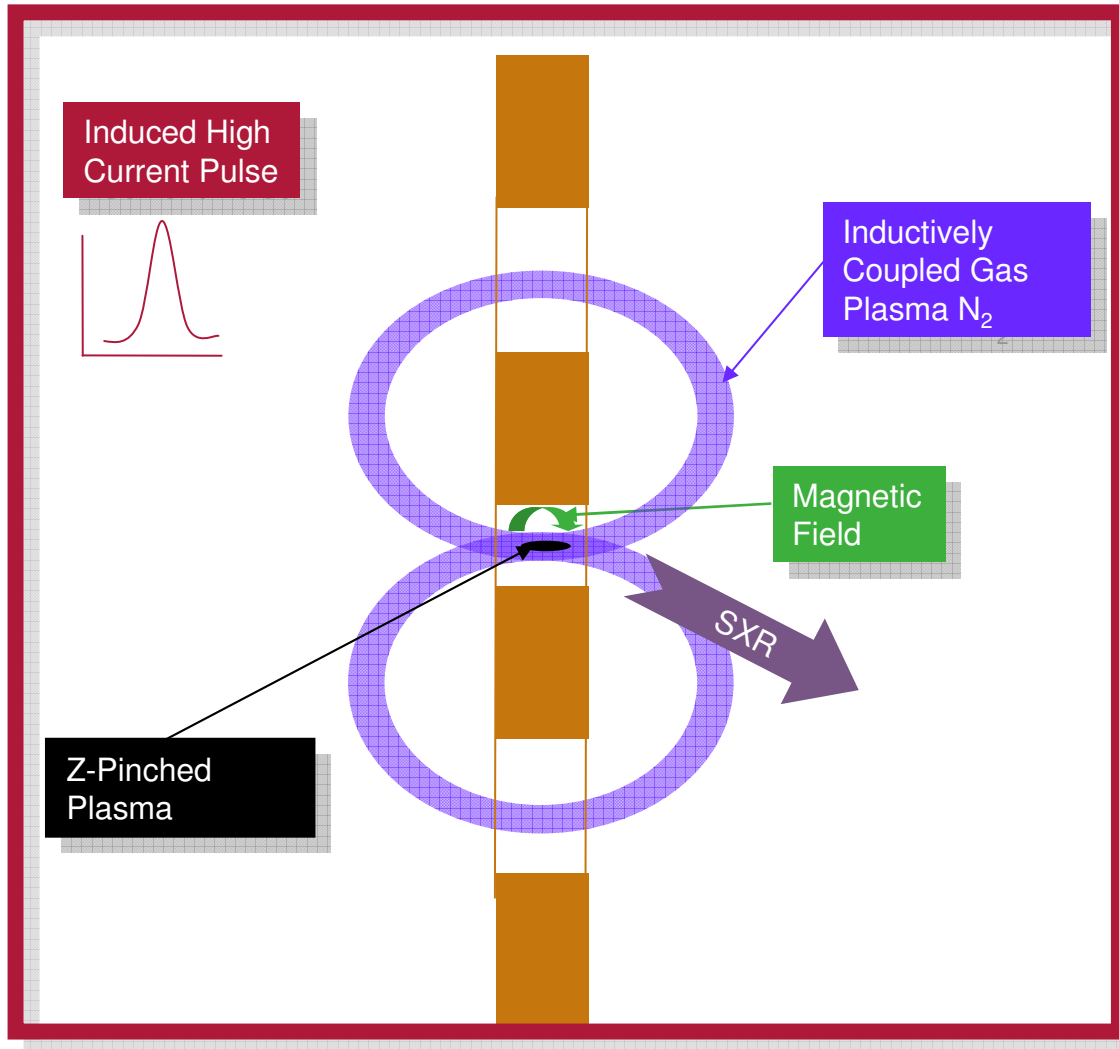
- High resolution x-ray images of the inner structures of biological cells
- Cell remains hydrated and frozen
- Soft x-ray 3-D microscopy for cell imaging pioneered at synchrotrons

Yeast cell 3-D images

C. Larabell – LBL

Published in Nature (2006)

Energetiq: Electrodeless Z-Pinch



- Unique inductive design eliminates electrodes and electrode current
 - No electrodes → no electrode debris
- Plasma is magnetically confined away from source components
 - Reduces debris further
- Low complexity

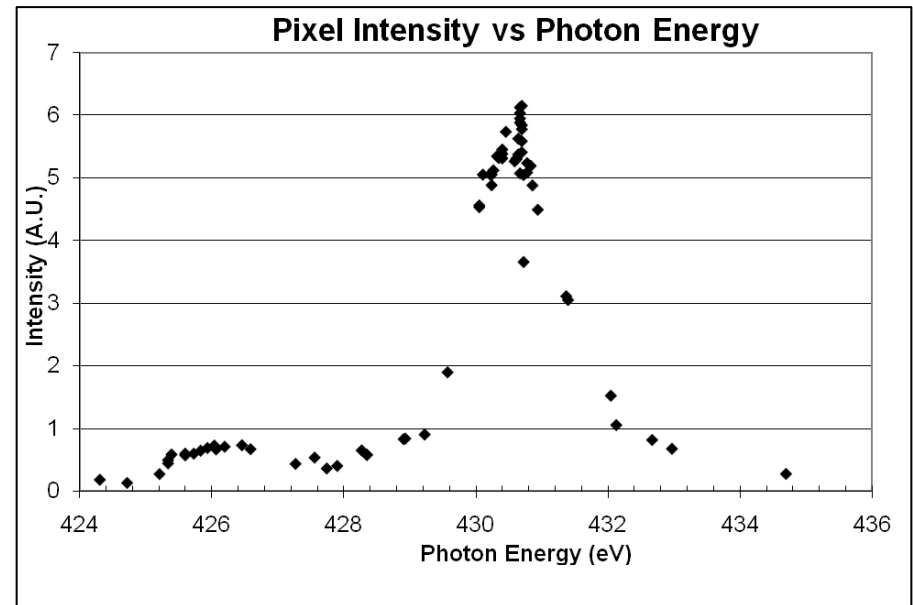
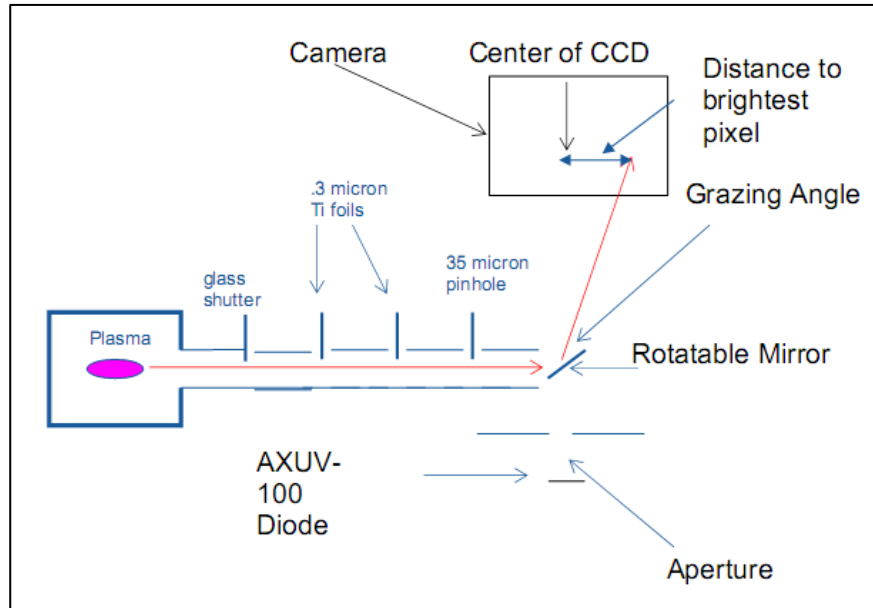
EQ-10 Source for SXR Technology Development

- Unique Electrodeless Design
 - Continuous operation
 - Repeatable performance
 - Stable output
- 2.88nm (430eV) High Brightness Operation
 - Up to 400 mW $\pm 1\%$ Power in 2π
 - Source size 800-1000 μm diameter (depends on source operating conditions)
- Cost effective, scalable design
 - Low cost per watt
 - Flexible Optical Interface



EQ-10R Remote Source

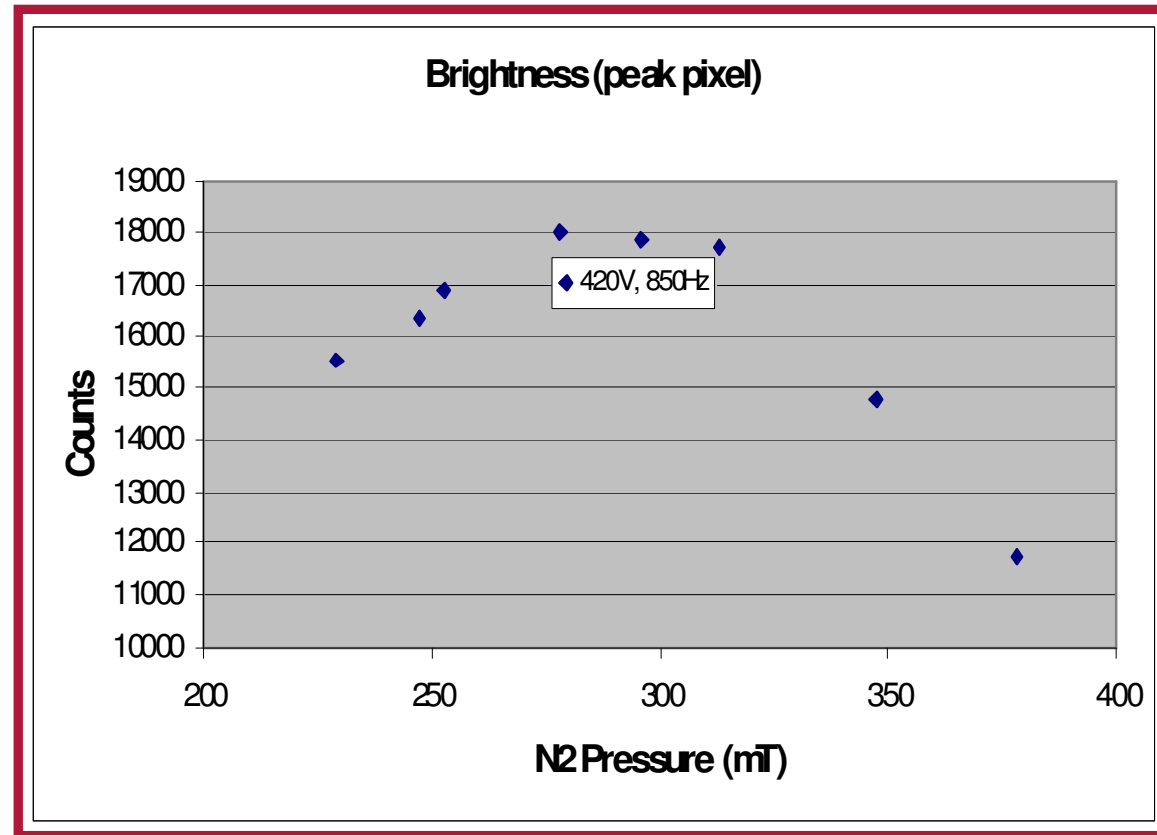
Source Characterization



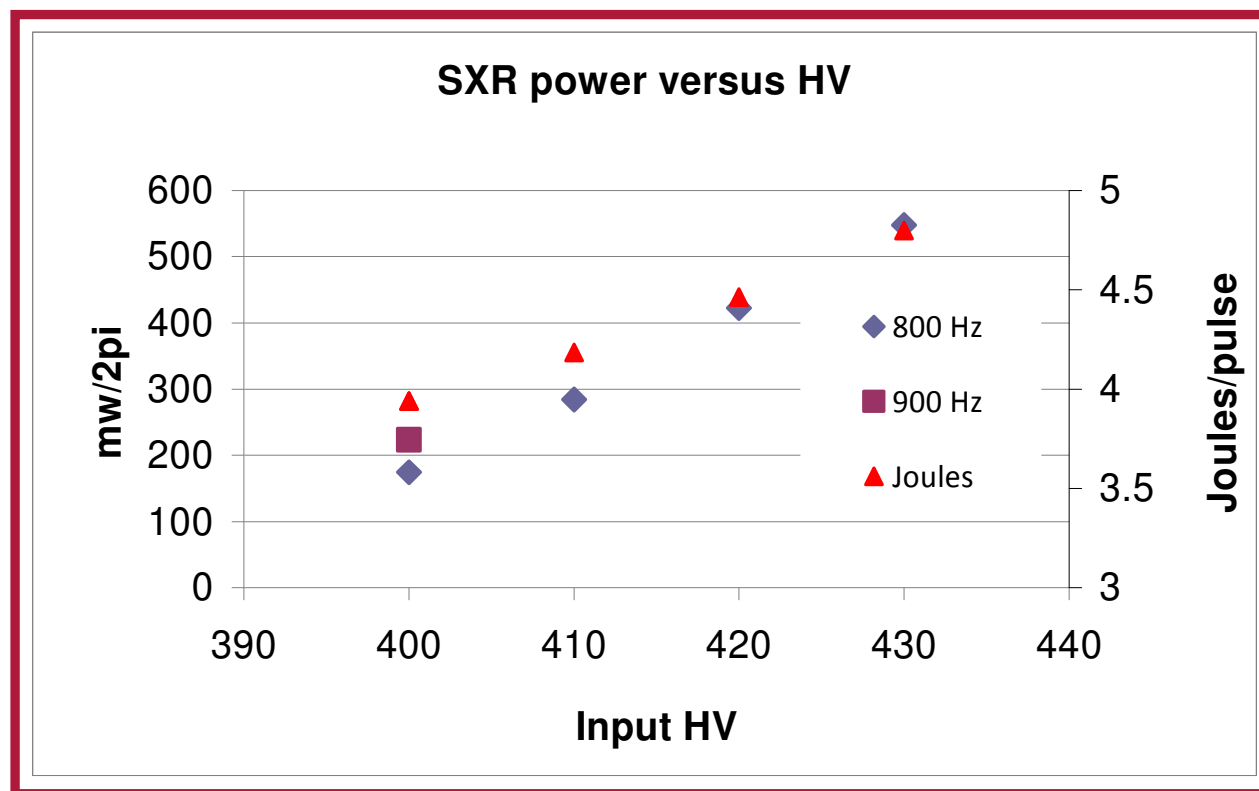
- Used rotatable, graded multilayer mirror as spectrometer and calibrated x-ray diode as a detector

Brightness

Brightness determined by looking at peak intensity of image



Power





Results of EQ-10SXR Incorporated into Xradia Soft X-ray microscope

Xradia nanoXCT-S220 Soft X-ray Microscope System



Microscope Chamber

Energetiq EQ-10SXR

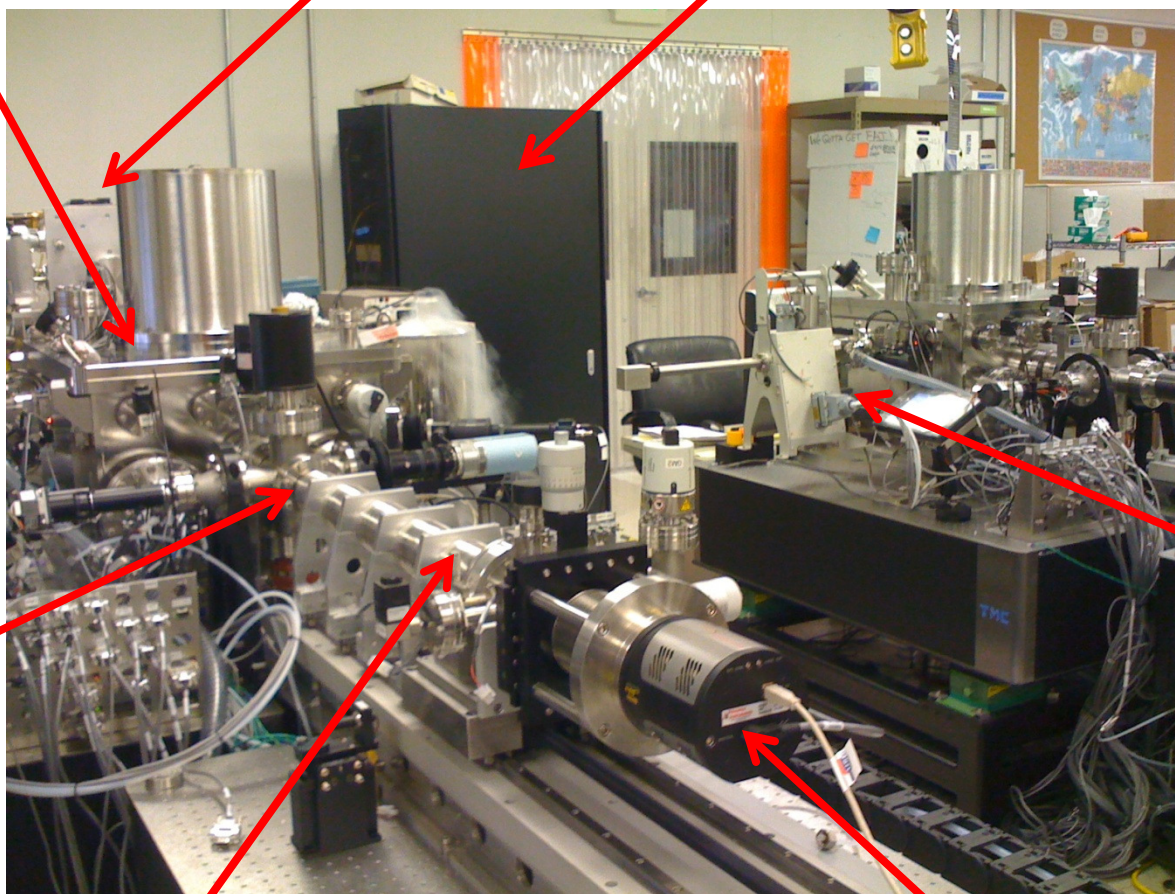
Electronics Rack

X-ray
Alignment
System

Cryo Sample
Transfer
System Docked
to Microscope

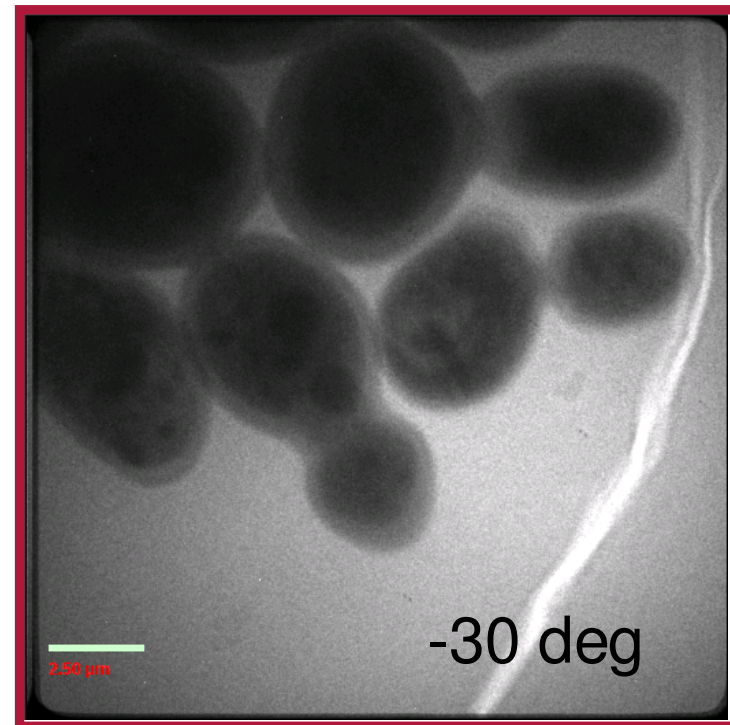
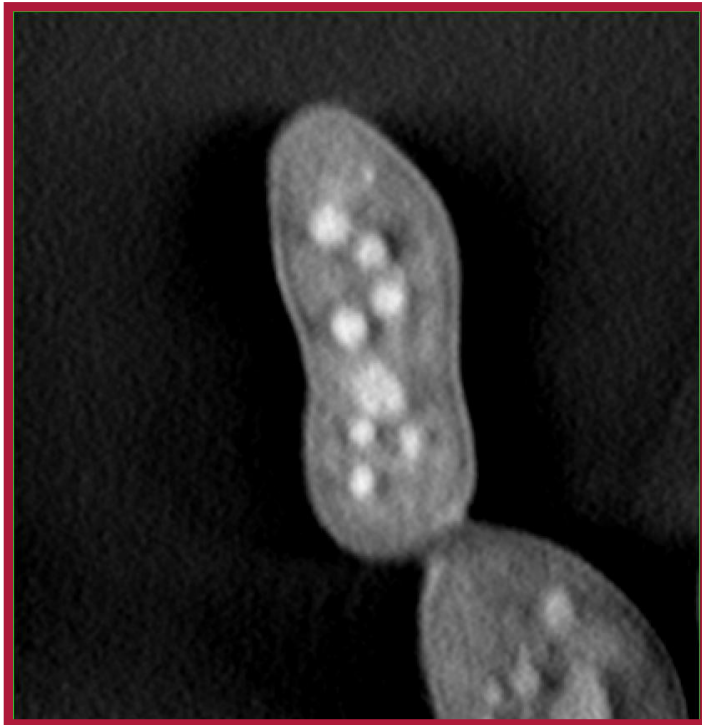
Variable Magnification Slide

CCD Camera



Yeast Cell Images with Soft X-ray Microscope

- Images of frozen hydrated yeast cells



Summary

- It is recognized that soft x-ray 3-D microscopy closes the gap between
 - Light microscopy (incl. fluorescence)
 - TEM microscopy
- Current imaging has been done on synchrotrons
- The Energetiq/Xradia Soft X-ray microscope offers comparable imaging without the need for a synchrotron!

Acknowledgements

- The team at Energetiq...
- The team at Xradia...
- National Institute of Health

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